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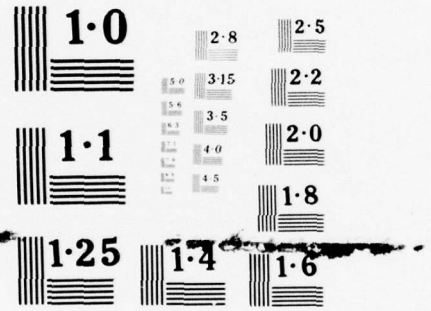

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Processing EMP-Related Flash-X-Ray Test Data with the TRANS2 Computer Program

November 1977

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U.S. Army Material Development

HDL-TM-77-30 Processing EMP-Related Flash-X-Ray Test Data with the TRANS2 Computer Program, by John F. W. Dietz

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When parameters, such as coupled currents, magnetic fields, Compton currents, etc., are measured at a flash x-ray facility, the measured voltages which represent these parameters are a function of the frequency response of the measuring system. By using a measured response (transfer) function for the measuring systems along with Fourier analysis, the computer program TRANS2 transforms measured voltages into the desired parameters.

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1. INTRODUCTION

The Tactical Environment Multiple Systems Evaluation Program (TEMSEP) is jointly funded by the Army and the Defense Nuclear Agency and is directed toward vulnerability assessments and hardening of tactical military equipment for tactical nuclear threats. TEMSEP complements the Multiple Systems Evaluation Program (MSEP), which is also directed toward vulnerability assessments and hardening of equipment for nuclear threats. Unlike TEMSEP, however, MSEP is directed towards stategic, rather than tactical, nuclear threats.

In the absence of threat-relatable simulation of source-region EMP environments, meaningful assessments of source-region EMP vulnerabilities of tactical equipment are feasible only through theoretical and controlled experimental evaluations of dominant source-region coupling mechanisms. The experimental evaluations are being performed at flash x-ray facilities, such as AURORA and HIFX (the High-Intensity Flash X-Ray), both at Harry Diamond Laboratories (HDL). These facilities are being used as partial simulation tools and as tools for validating theory.

During the experiments at AURORA and HIFX, parameters such as coupled currents, magnetic fields, and Compton currents are measured with sensors such as current *probes*, *Moebius loops*, and *Rogowski* coils. Typically, the sensors are part of a sensor-cable-balun system such as the one shown in the block diagram of figure 1.

Because it is less noisy in a radiation environment than most other cables, twinax cable is normally used to transmit the sensor output from the test cell into the data room. Unfortunately, twinax cable is relatively lossy, and the signal loss is frequency dependent. When twinax cable is used, a balun is needed to match the 78-Ω impedance of this cable to the 50-Ω impedance of the cable used in the data room.

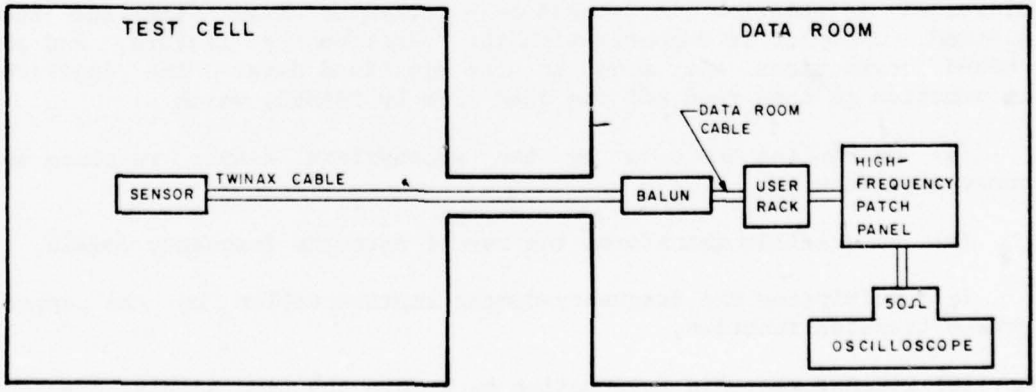

Figure 1. Block diagram of measuring system used at AURORA.

Each sensor exhibits a particular response to a given signal, and this response is degraded by the cables and balun through which the signal passes. Thus, the voltages measured by the oscilloscopes in the data room represent the response of the sensor-cable-balun system to a particular phenomenon occurring in the test cell, and these voltages must be somehow "transformed" into the parameter being measured.

The response of the sensor-cable-balun system to input signals can be measured with a network analyzer. This response, represented by the transfer function measured by the network analyzer, provides the amplitude of the output voltage and the phase difference between this voltage and the input signal for an input signal of unit amplitude over a wide range of frequencies. If a current probe is used to measure it, the transfer function is actually the admittance of the measuring system, and the input signal can be found from the relationship

$$I(\omega) = Y(\omega)V(\omega)$$

where I is the input current, Y is the admittance (transfer function) of the measuring system, V is the measured voltage, and ω is the angular frequency.

The computer program TRANS2 uses this transfer function information to transform oscilloscope voltage measurements into the parameters being measured, even if they are not simply currents.

2. DATA-PROCESSING PROCEDURE

The data-processing procedure which is used to accomplish this transformation is this: The oscilloscope pictures are digitized to provide information which can be manipulated by a digital computer. The digitized information is stored on a computer disk file and then plotted. The plot is compared with the oscilloscope picture, and any needed corrections are made to the digitized data. The digitized information is then read off the disk file by TRANS2, which

(a) multiplies the data by the appropriate sensor response and conversion factors,

(b) numerically transforms the result into the frequency domain,

(c) multiplies the frequency-domain representation by the appropriate transfer function,

(d) transforms this information back into the time domain,

(e) integrates the result, if necessary, and

(f) plots the resultant information.

The plotted information represents the time histories of the actual fields, currents, etc., occurring at the sensor locations during the AURORA or HIFX tests, and not merely the measured voltages. These plots can then be compared with theoretical predictions of test results.

3. PROGRAM DFILE

A listing of the program DFILE, which is used to put the digitized data onto a computer disk file, is presented in appendix A. Figure 2 shows a sample deck needed to run the program.

```
//JFD1ADF1   JOB   (HK3020),'JFWDIETZ',CLASS=A,MSGLEVEL=(2,1)
//STEP1   EXEC TRANS,NAME='&&DATA'
//SYSIN    DD  *
 &OUTPUT                    &END
     data set #1
          °
          °
          °
     data set #n
(7/8/9) CARD
/*
//STEP1   EXEC ANAFORT,OUT=X
//SYSIN    DD  *

     source deck

/*
//GO.FT12F001  DD DSN=*.STEP1.STP.FT12F001,DISP=(OLD,DELETE),
// DCB=(RECFM=VS)
//GO.FT14F001  DD DISP=(NEW,CATLG),VOL=SER=USER02,
// UNIT=SYSDA,SPACE=(TRK,(2,2)),
// DSN=HK3020.CR362022
//
```

Figure 2. Sample deck for DFILE.

3.1 Description of DFILE

The procedure TRANS,* which transforms the digitizer output into usable data, is executed and the data are written to logical unit No. 12. DFILE calls the subroutine READIT, which reads the data from logical unit No. 12. The subroutine CSTOUT, contained in the ANAPAC[1] library and attached by the ANAFORT* procedure, is then called. CSTOUT checks the time ordering of the independent array and casts out those points not in an ascending time order.

DFILE converts the data to double precision to increase the accuracy of the data-processing effort and calls WRITED, which writes the double-precision data to logical unit No. 14 so that it can be cataloged during the GO step. Finally, DFILE prints the double-precision data.

3.2 DFILE Sample Deck

A few comments concerning the sample deck shown in figure 2 are now appropriate. The namelist entitled "OUTPUT" contains two logical variables, LIST and PLOT, which are input to TRANS.* A value of TRUE for either LIST or PLOT turns on either the printing or the plotting of the data sets, respectively. This printing or plotting is performed by TRANS and occurs before CSTOUT corrects the time ordering. Second, the last card in each data set must be a (7/8/9) card, and there must be an extra (7/8/9) card after the last data set. Finally, the name of the data file cataloged by DFILE is given by the DSN parameter on the last executable card.

4. PROGRAM TRANS2

After the digitized data are placed on file and verified to be correct, TRANS2 must be run to transform the data into the measured fields, currents, etc. TRANS2 is currently maintained as an UPDTE[2] file so that temporary changes in the program can be readily made. A sample deck needed to create an UPDTE[2] file containing TRANS2 is shown in figure 3. A listing of TRANS2 is presented in appendix B. Definitions of the input parameters for TRANS2 are presented in section 4.1, followed by a description of how the program works and, finally, by a discussion of the sample deck needed to run TRANS2 (sect. 4.3).

---

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

[2] *IBM OS/VS Utilities Manual, GC35-0005-4 (September 1976).*

**From recommendations by Egon Marx and Thomas V. Noon, Harry Diamond Laboratories (1976).*

```
//JFD1CTR2   JOB   (HK3020),'JFWDIETZ',CLASS=C
//        EXEC PGM=IEBUPDTE,PARM=NEW
//SYSPRINT DD  SYSOUT=A
//SYSUT2   DD  UNIT=SYSDA,DISP=(NEW,CATLG),VOL=SER=USER02,
//             DSNAME=HK3020.TRANS2,SPACE=(TRK,(25,2)),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=4080)
//SYSIN    DD  *
./ ADD LIST=ALL
./ NUMBER NEW1=1000,INCR=1000

      source deck
./ ENDUP
/*
//
```

Figure 3. Sample deck to create UPDTE file for TRANS2.

4.1 Input Parameters for TRANS2

Card No. 1: FORMAT (2I10)

NDSETS — Number of data sets to be processed.

ISAME — If equal to one, the input parameters for the first data set are used for all the data sets; otherwise, input parameters must be provided for each data set.

Card No. 2: FORMAT (7I10)

NOFF — Number of data points removed from the front of the pulse.

NOFFR — Number of data points removed from the rear of the pulse.

INVERT — If equal to one, the pulse is inverted; otherwise, not.

IZERO — If equal to one, the amplitudes of the first and last data points are set equal to zero; otherwise, not.

IPLOT — If equal to one, the input digitized data are plotted after any necessary time shift is made; otherwise, not.

IFILE — If equal to one, the processed data are written to logical unit No. 9 so that they can be cataloged as a disk file; otherwise, not.

ISENSR Denotes the type of sensor used to produce the data:

1 = Current probe used to measure current on truncated cylinder banjo.[3]

2 = Current probe used to measure current on single wire.

3 = Current probe (Rogowski coil) used to measure Compton current.

4 = Moebius loop.

5 = Current probe on pie pan.[3]

6 = One-turn Rogowski coil.

Card No. 3: FORMAT (2I10)

IPLTC If equal to one, coupled-current output from SAPSC[4] is plotted on the same graph as the processed data; otherwise, not. Set equal to one only if ISENSR=1.

NCUR If equal to one, SAPSC output is plotted for the first measurement position; otherwise, for the second measurement position. Set equal to one only if ISENSR=1.

Card No. 4: FORMAT (I10, E10.3, I10)

NSTAR Number of frequency and time points used by the fast Fourier transform (FFT) (must be a multiple of two).

FMAX Maximum frequency used by the FFT.

KPLOT If equal to one, frequency-domain results are plotted; otherwise, not.

Card No. 5: FORMAT (3I10)

NTRANS Number of transfer function amplitude points (25 or less).

---

[3] *John F. W. Dietz, Daniel J. Spohn, and George Merkel, Status of the Tactical Environment Multiple Systems Evaluation Program (TEMSEP), Harry Diamond Laboratories TM-77-23 (September 1977).*

[4] *E. R. Parkinson, SAPSC: A Two-Dimensional Close-in EMP Coupling Analysis Code, Science Applications Inc. SAI-75-506-AQ (October 1975).*

JPLOT If equal to one, the transfer function amplitude and phase (if used) are plotted; otherwise, not.

IPHASE If equal to one, phase is included in the transfer function; if not, amplitude only.

Card No. 6: FORMAT (4(2E10.3)); (one to seven cards)

FTRANS(I) Frequency (Hz) at which transfer function amplitude value is given.

ATRANS(I) Amplitude value (amps/volt) of measured transfer function.

Card No. 7: FORMAT (I10, E10.3) (used only if IPHASE=1)

NPHASE Number of transfer function frequency points (25 or fewer).

TRETRD Amount of time (seconds) by which the input pulse must be retarded if the transfer function includes phase.

Card No. 8: FORMAT (4(2E10.3)) (one to seven cards) (used only if IPHASE=1)

FPHASE(I) Frequency (Hz) at which transfer function phase value is given.

PHASE(I) Phase value (degrees) of measured transfer function.

4.2 Description of TRANS2

TRANS2 was originally written to operate on a CDC 6600 computer and then converted to run on an IBM 370-series computer. Because of the short word length of the IBM computer, it was felt that the precision of the variables and functions within the program should be increased. To avoid the necessity of making a substantial number of changes to the program, the AUTODBL(DBL) option, which automatically doubles the precision of all real and complex variables and library functions, is used. So that the precision of the plot label variables is not doubled, these variables are declared to be integers.

After the plot labels are defined, a number of arrays are equivalenced to reduce storage. If the dimensions of any of these arrays are changed, or the positions of the arrays within the program are changed, the EQUIVALENCE statements must be altered to reflect these changes.

The first data card, containing NDSETS and ISAME, is then read. NDSETS is the number of data sets on file which are to be processed, and the remainder of TRANS2 consists of a DO loop that is executed NDSETS times, once for each data set.

The first statement inside the loop calls subroutine READTP, which reads the time (T) and amplitude (FT) data pairs from logical unit No. 8. If the number of data pairs (NPTS) exceeds 300, the program is terminated because the dimensions of T and FT would be exceeded. Next, the input parameters are read and printed, unless ISAME=1 and other than the first data set is being processed.

NOFFR data points are then removed from the rear of the pulse. This feature is useful if the oscilloscope picture is accidentally digitized beyond the region of interest. The pulse is inverted, if desired, and NOFF extraneous points are removed from the front of the pulse.

If phase is included in the transfer function, the digitized pulse is now retarded by TRETRD seconds. Since it takes a finite amount of time for the sensor to respond to the input signal and for the sensor output to pass through the cables and the balun before it reaches the oscilloscope, the time frame at the oscilloscope is retarded from the time frame at the sensor. Because use of the phase relationship between the sensor input and the cable output would advance the output forward into the sensor time frame, the digitized pulse must be retarded so that it is not advanced into negative time.

The amount of retardation needed for a sensor-cable-balun system can be measured approximately by sending a pulse through the system. Unfortunately, the amount of retardation depends to some extent upon the frequency content of the pulse. Because of this dependence, it may be necessary to make a preliminary run of TRANS2, with TRETRD slightly larger than the expected value. After the processed pulse is examined to determine at what time it actually starts, TRETRD can be adjusted accordingly, and TRANS2 can be run again with the correct value of TRETRD.

Next, the amplitudes of the first and last digitized points are set equal to zero, if desired, and the retarded data are plotted with the DRAW4 plotting routine,[1] if desired.

---

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

The digitized data are then multiplied by sensor response functions which are not included in the transfer function. The following list describes the response functions presently being used.

(1) The current probe output is multiplied by the number of resistors (20) in the banjo to provide the total coupled current.

(2) The current probe output is simply multiplied by 1, since the total current is measured by the probe.

(3) The current probe output is divided by the effective area of the coil to provide the Compton current density. At present, an effective coil diameter of 1.875 in. (4.76 cm) has been assumed for the current probe with a center opening of 1.625 in. (4.13 cm).

(4) Because the transfer function of the Moebius loop-cable-balun system cannot be measured directly, the Moebius loop is replaced by a current probe to make the transfer function measurement. If this transfer function is multiplied by the impedance of the current probe, the result is the transfer function of the cable-balun system. Multiplying this result by the sensor response of the Moebius loop $(1 \text{ weber}/m^2 s)/(1.14 \times 10^{-3} \text{ V})$ then provides the value of B-dot. At present, the impedance of the current probe is assumed to be simply 2.4 Ω, although it is actually a function of frequency.

(5) The current probe output is simply multiplied by 1, since the total current is measured by the probe.

(6) If the transfer function is measured with a current probe, the output of the one-turn Rogowski coil must be multiplied by the impedance (2.4 Ω) of the current probe. The output of the one-turn Rogowski coil must then be multiplied by the sensor response of $1. \times 10^{-7}$/volume to provide the Compton current density. The volume presently being used is 5×10^{-2} m^3.

Next, the frequency spacing, DF, and the time spacing, DT, are calculated. The frequency spacing is the interval between data points after the data are transformed into the frequency domain, and the time spacing is the interval between the data points after the data are transformed back into the time domain.

The data are then linearly interpolated with CLINTD,[1] which also extends the data array to fulfill the requirement that the maximum time value, TMAX, equals 1/DF. The number of equispaced time points

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

extending across the range of the original data, NTP, is then found so that the proper time interval of the processed data can be plotted later. The equispaced data are then transformed into the frequency domain by FFTD, which is a double-precision version of FFT.[1]

The transfer function amplitude and phase information is available at only a limited number of frequencies. To provide transfer function information at all the frequency values used by FFT, a cubic spline fit to the data is performed. Initially, the spline coefficients are calculated by the subroutine SPLICO, which uses the technique discussed by Pennington.[5] The coefficients for the amplitude and the phase values of the transfer function are stored in the arrays COEF and COEFP, respectively.

Various initializations are performed, and DO loop 30 is then executed to multiply the frequency-domain representation of the data by the transfer function. Since half aliasing[1] is used by the Fourier transform, only the first half of the data array plus one point (NS21 points) is multiplied by the transfer function.

If the frequency value is outside the range of the spline fit to the transfer function amplitude or phase information, the subroutine ENDFIT is called. During the first execution of ENDFIT for any particular fit (KFIT=1), fit coefficients are calculated, and a calculation of the appropriate transfer function value is made. During subsequent executions, these coefficients are not calculated again, but a calculation of the transfer function is made. The following four fits are presently being used:

(1) The transfer function amplitude value is set equal to 1000 if the frequency is below that of the spline fit information. It has been assumed that the user will supply transfer function amplitude information for at least one frequency point below the second frequency value (equal to the frequency spacing 1 × DF) used by FFT, so that the only low-frequency value for which an amplitude value is needed is 0 Hz. It was felt that some large value, such as 1000, was appropriate for the 0-Hz frequency point, since the balun should not transmit dc signals.

(2) A decreasing exponential is fit to the high-frequency end of the transfer function amplitude information. Since the Tektronix 556 oscilloscopes used at AURORA have a high-frequency 3-dB cutoff at 50 MHz, it was felt that any energy present in the digitized data at

---

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

[5] *Ralph H. Pennington, Introductory Computer Methods and Numerical Analysis (2nd ed.), MacMillan, Inc. (1970).*

frequencies much beyond 50 MHz is probably due to the process of digitizing the data and should be filtered out. Therefore, it is suggested that the last value of the measured transfer function which the user provides to TRANS2 be at a frequency of 50 MHz. ENDFIT will then exponentially decrease the value of the transfer function amplitude until it reaches 0 at 100 MHz. Due to sampling theorem considerations,[6] the value of FMAX should always be at least twice the value of the frequency at which the transfer function amplitude drops to 0.

(3) The transfer function phase is set equal to 180 deg if the frequency is below that of the spline fit information. Again, it has been assumed that the user will supply at least one transfer function value below a frequency equal to 1 × DF. Examination of the output of the network analyzer indicates that a value of 180 deg at 0 Hz is reasonable.

(4) The transfer function phase is fit to a straight line passing through the last two points if the frequency is above that of the spline fit information. Examination of the output of the network analyzer indicates that this fit is reasonable.

If the frequency value is within the range of the transfer function information provided by the user, the subroutine SPLINE is called to calculate the proper value of the transfer function using the coefficients calculated by SPLICO. The equations used are presented in Pennington's book,[5] but the search technique is not the same as that presented by Pennington. The frequency at which the transfer function is needed is compared with increasing values of the frequency intervals of the cubic splines until the proper frequency interval is found. The transfer function is calculated using the spline coefficients for the proper interval, and a pointer (KSTART) is used to "remember" this interval. During the following call of SPLINE, the search begins with the interval designated by KSTART, rather than with the first interval. KSTART is updated and, during each subsequent call of SPLINE, the first interval used during the search is the interval used for the SPLINE fit during the last call. This process works because the values of the frequency increase with each call of SPLINE.

After the correct values of the transfer function amplitude and phase values are calculated, the frequency-domain representation is multiplied by the transfer function, given by

---

[5] *Ralph H. Pennington, Introductory Computer Methods and Numerical Analysis (2nd ed.), MacMillan, Inc. (1970).*

[6] *George R. Cooper, and Clare D. McGillem, Methods of Signal and System Analysis, Holt, Rinehart, and Winston, Inc. (1967).*

$$TF = Ae^{-j\theta}$$

where A is the amplitude (in amps/volt) and θ is the phase (in radians) of the transfer function.

Before the end of DO loop 30, various arrays are filled for plotting. FPLT contains the frequency points, AMPPLT contains values of the transfer function amplitude, PHIPLT contains values of the transfer function phase (in degrees), and FAMP contains the frequency-domain representation of the processed data.

If the user wishes, the transfer function amplitude and phase values and the frequency-domain results are then plotted as a function of frequency. If ISAME=1, the transfer function is plotted only once.

Next, FFTAD, a double-precision version of FFTA,[1] is called to transform the frequency-domain results into the time domain. Because an inverse FFT can cause an overall amplitude shift, the amplitude at the first time point (FTT1) is subtracted from all the other values of the processed data.

The processed data are then plotted. If ISENSR=1 and IPLTC=1, coupled current predictions made by the computer program SAPSC[4] are plotted on the same graph as the processed data. This SAPSC information is read from logical unit No. 10. Since the plot array (CURRNT) is equivalenced to the first SAPSC coupled-current array (CURNT1), the current predicted for measurement position 1 is used unless NCUR is not equal to 1. If NCUR is not equal to 1, the plot array (CURRNT) is set equal to the SAPSC coupled-current array (CURNT2) for position 2.

When Moebius loop (ISENSR=4) data are processed, not only B-dot is plotted, but also the tangential H-field is plotted. H is calculated by dividing B by the permeability of free space (1.26×10^{-6} henry/m), and integrating the result by using the trapezoidal rule.[7]

When one-turn Rogowski (ISENSR=6) coil data are processed, both J and J-dot are plotted. J is calculated by using the trapezoidal rule to integrate the J-dot results.

---

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

[4] *E. R. Parkinson, SAPSC: A Two-Dimensional Close-in EMP Coupling Analysis Code, Science Applications, Inc. SAI-75-506-AQ (October 1975).*

[7] *Francis Scheid, Schaum's Outline of Theory and Problems of Numerical Analysis, McGraw-Hill (1968).*

Finally, if desired, the processed data are written to logical unit No. 9 so that they can be cataloged as a disk file and used at some future time.

4.3 TRANS2 Sample Deck

A sample deck needed to run TRANS2 from an UPDTE file is shown in figure 4. Information concerning the IEBUPDTE utility has been given by IBM.[2] If TRANS2 is to be run as shown in figure 4, at least one CHANGE card must be present in the deck, even if the change is merely to insert a comment card somewhere.

The data set name (DSN) associated with logical unit No. 8 should correspond to the file containing the data to be processed. The DSN associated with logical unit No. 10 should correspond to the file created by the computer program SAPSC. If SAPSC output is not to be plotted on the same graph as the processed data, the DD cards associated with logical unit No. 10 should be removed from the deck. The DSN associated with logical unit No. 9 should be the user's choice of the

```
//JFD5CTR2   JOB   (HK3020,,5),'JFWDIETZ',CLASS=C,MSGLEVEL=(2,1)
//         EXEC PGM=IEBUPDTE
//SYSPRINT DD  SYSOUT=A
//SYSUT1   DD  DSNAME=HK3020.TRANS2,DISP=(OLD,PASS,CATLG)
//SYSUT2   DD  DSNAME=&&NEWPL,DISP=(NEW,PASS),UNIT=VIO,DCB=*.SYSUT1,
// SPACE=(TRK,(10,10))
//SYSIN    DD  *
./ CHANGE

      changes

./ ENDUP
//         EXEC ANAFORT,PARM.FORT='AUTODBL(DBL)',F1=,OUT=X
//FORT.SYSIN  DD  DSN=&&NEWPL,DISP=(OLD,PASS)
//GO.FT08F001   DD   DSN=HK3020.CR35,DISP=SHR
//GO.FT09F001   DD   DSN=HK3020.TRANSOUT,DISP=(NEW,CATLG),UNIT=SYSDA,
// SPACE=(TRK,(1,1)),VOL=SER=USER02
//GO.FT10F001   DD   DSN=HK3020.SAPSCOUT,DISP=SHR
//GO.SYSIN DD  *

     data cards

/*
//
```

Figure 4. Sample deck for TRANS2.

---

[2] *IBM OS/VS Utilities Manual, GC35-0005-4 (September 1976).*

name of a file on which the processed data are to be stored. If the user does not wish to retain the processed data on a disk file, the DD card associated with logical unit No. 9 should be removed from the deck.

4.4 TRANS2 Sample Plots

Figures 5 through 9 contain examples of some of the plots which can be produced by TRANS2.

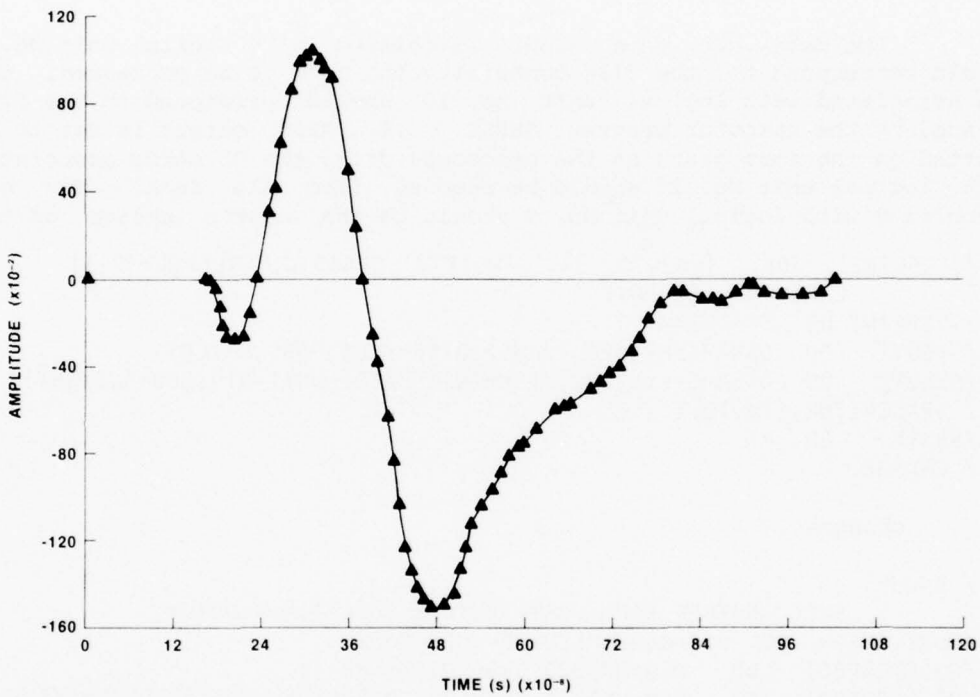

Figure 5. Typical plot of digitized data after they have been shifted.

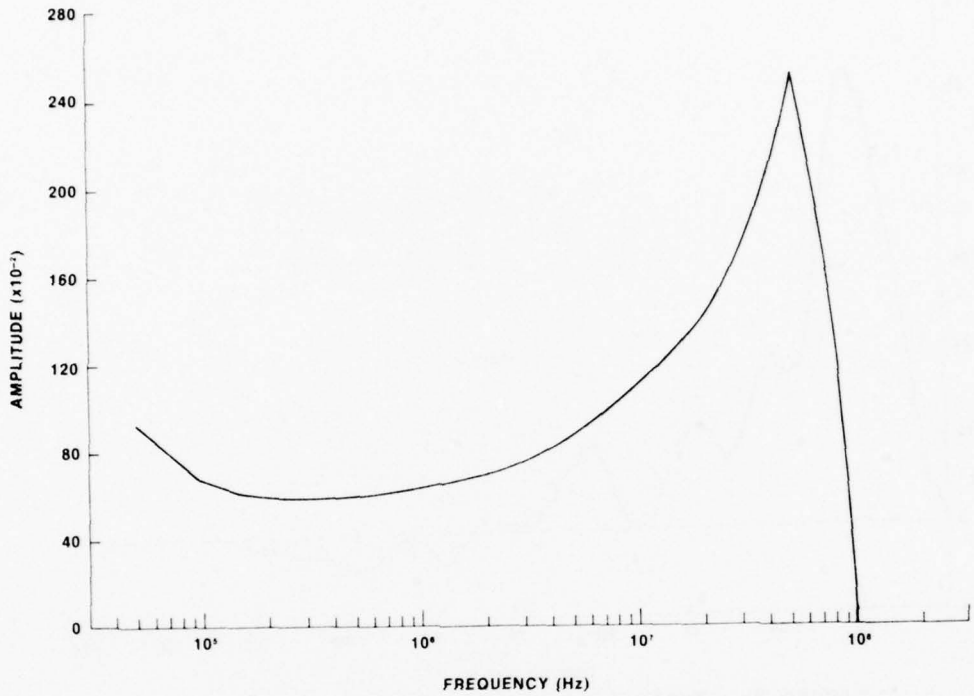

Figure 6. Typical plot of transfer function amplitude.

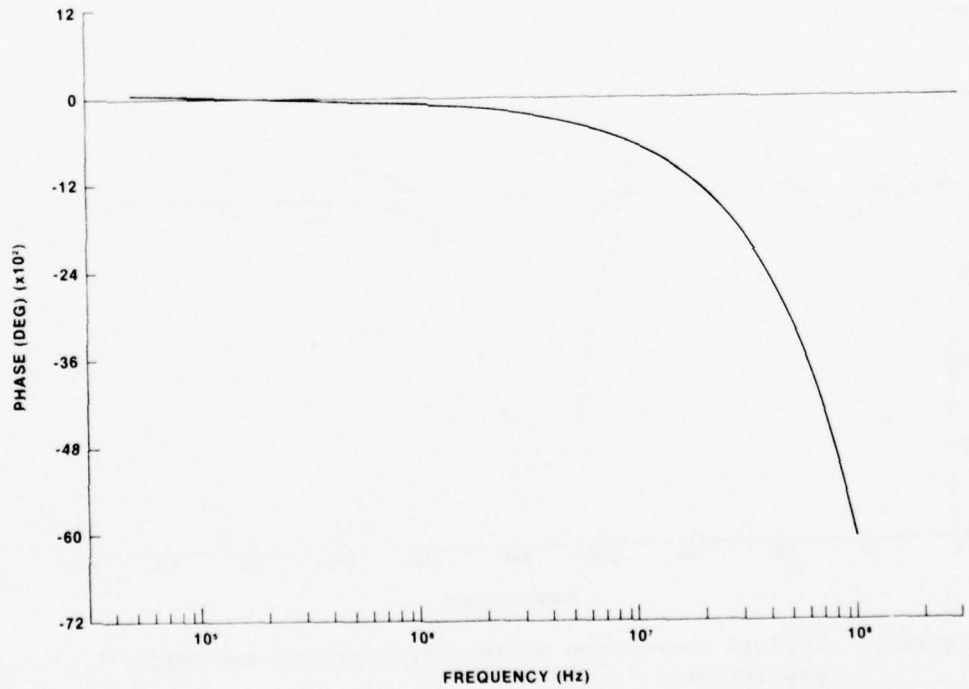

Figure 7. Typical plot of transfer function phase.

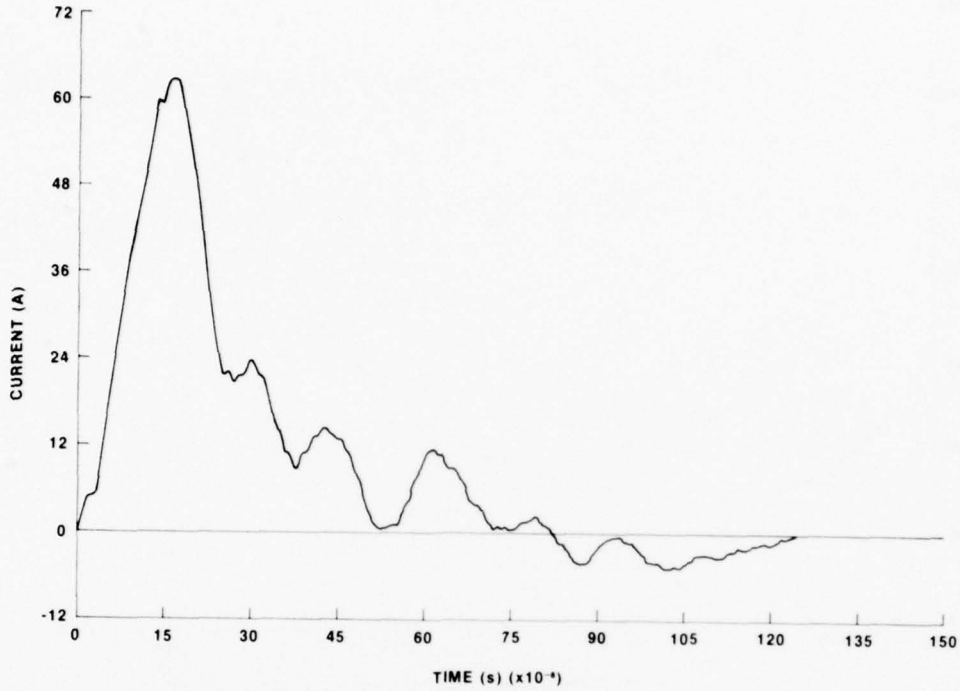

Figure 8. Typical pie-pan response.

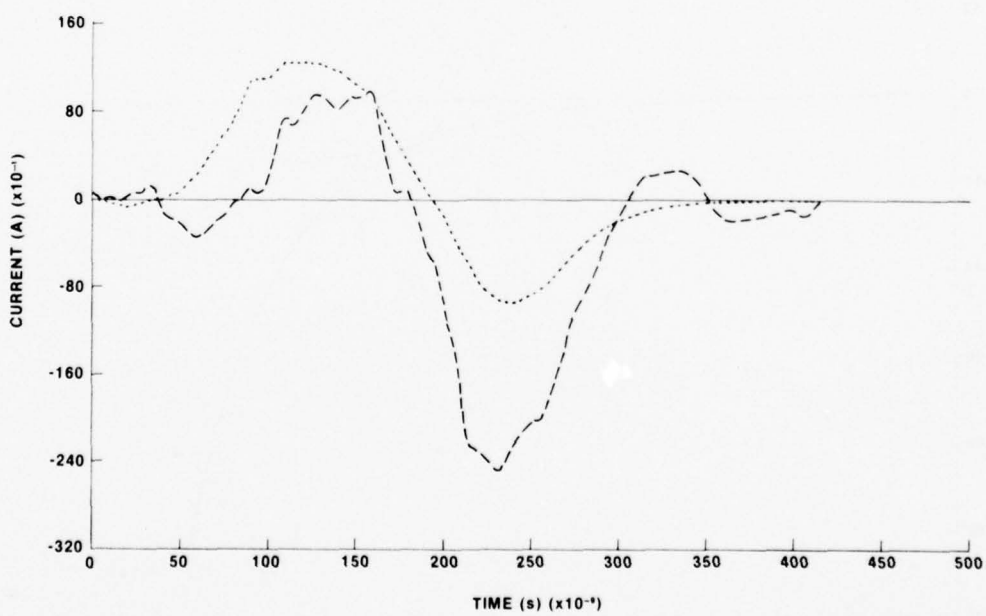

Figure 9. Typical comparison of measured current and SAPSC predictions.

5. PROGRAM PUNCH

If a permanent record of the processed data is needed, the program PUNCH can be executed. A listing of PUNCH is presented in appendix C, and figure 10 shows a sample deck needed to run PUNCH.

```
//JFD1APUN  JOB  (HK3020),'JFWDIETZ',CLASS=A,MSGLEVEL=(2,0)
//STEP1   EXEC FORTPCLG,PARM.FORT='NOSOURCE,NOMAP'
//FORT.SYSIN DD *

     source deck


/*
//GO.FT10F001  DD  DISP=SHR,DSN=HK3020.TRANSOUT
//
```

Figure 10. Sample deck for PUNCH.

5.1 Description of PUNCH

PUNCH transforms the processed data file created by TRANS2 into punched cards. The first punched card contains the title punched in 20A4 format. The second card contains the number of data pairs punched in I10 format. All subsequent cards contain the time and amplitude data pairs punched in 3(2E12.4) format. At present, PUNCH converts the processed data from double to single precision before punching them.

5.2 PUNCH Sample Deck

The DSN associated with logical unit No. 10 should be the name of the file containing the information to be punched.

6. PROCEDURE PURGE

It is suggested that, to save storage charges, all data files be deleted after the data have been processed. This deletion can be accomplished easily with the PURGE* procedure.

**From recommendations by Egon Marx and Thomas V. Noon, Harry Diamond Laboratories (1976).*

7. CONCLUSIONS

The program TRANS2 has been used successfully to transform digitized data taken at AURORA into the parameters being measured, such as coupled currents, Compton currents, etc. When phase is included in the transfer function, the user may initially have some difficulty choosing the proper time shift to use, but as the user becomes more familiar with the program and the data being processed, this choice should become less difficult. I would suggest that any potential user of TRANS2 have some knowledge of Fourier transforms and the sampling theorem before attempting to use this program. A poor choice of some input parameters, such as NSTAR and FMAX, could result in the data being improperly processed.

LITERATURE CITED

(1) Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).

(2) IBM OS/VS Utilities Manual, GC35-0005-4 (September 1976).

(3) John F. W. Dietz, Daniel J. Spohn, and George Merkel, Status of the Tactical Environment Multiple Systems Evaluation Program (TEMSEP), Harry Diamond Laboratories TM-77-23 (September 1977).

(4) E. R. Parkinson, SAPSC: A Two-Dimensional Close-in EMP Coupling Analysis Code, Science Applications Inc. SAI-75-506-AQ (October 1975).

(5) Ralph H. Pennington, Introductory Computer Methods and Numerical Analysis (2nd ed.), MacMillan, Inc. (1970).

(6) George R. Cooper, and Clare D. McGillem, Methods of Signal and System Analysis, Holt, Rinehart, and Winston, Inc. (1967).

(7) Francis Scheid, Schaum's Outline of Theory and Problems of Numerical Analysis, McGraw-Hill (1968).

APPENDIX A.--A LISTING OF THE PROGRAM DFILE

```
 LEVEL 2.1  (JULY 75) OS/360  FORTRAN H EXTENDED PLUS DATE 77.061/15.02.51 PAGE    1

REQUESTED OPTIONS: XL,GOSTMT,XREF,MAP,NODECK

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT XREF NOALC
                   NOASF NOTERMINAL FLAG(I) XL

                      FUNCTIONS INLINE ARE:   NONE


                C     PROGRAM DFILE
                C
   ISN 0002           REAL*4 TP(400),FTP(400),TITLE(20)
   ISN 0003           REAL*8 TPD(400),FTPD(400)
   ISN 0004           REWIND 12
   ISN 0005           REWIND 14
   ISN 0006         5 CALL READIT(12,TP,FTP,NPTS,TITLE,&10,&20)
                C
                C     CAST OUT BAD POINTS
                C
   ISN 0007           CALL CSTOUT(TP,FTP,NPTS)
   ISN 0008           DO 69 I=1,NPTS
   ISN 0009           TPD(I) = TP(I)
   ISN 0010           FTPD(I) = FTP(I)
   ISN 0011        69 CONTINUE
   ISN 0012           CALL WRITED(14,TPD,FTPD,NPTS,TITLE)
   ISN 0013           WRITE(6,300) (TITLE(I),I=1,20)
   ISN 0014       300 FORMAT(1H1,20A4)
   ISN 0015           WRITE(6,400) NPTS
   ISN 0016       400 FORMAT(//9X,' NO. OF DATA PAIRS',I6//)
   ISN 0017           NROW = NPTS/4
   ISN 0018           NLEFT = MOD(NPTS,4)
   ISN 0019           N1 = 0
```

```
ISN 0020          N2 = 0
ISN 0021          N3 = 0
ISN 0022          IF(NLEFT.EQ.0) GO TO 4
ISN 0024          IF(NLEFT-2) 1,2,3
ISN 0025        1 N1 = 1
ISN 0026          GO TO 4
ISN 0027        2 N1 = 1
ISN 0028          N2 = 1
ISN 0029          GO TO 4
ISN 0030        3 N1 = 1
ISN 0031          N2 = 1
ISN 0032          N3 = 1
ISN 0033        4 N1 = N1 + NROW
ISN 0034          N2 = N1 + N2 + NROW
ISN 0035          N3 = N2 + N3 + NROW
ISN 0036          WRITE(6,600)
ISN 0037      600 FORMAT(4(13X,4HTIME,7X,9HAMPLITUDE))
ISN 0038          WRITE(6,500) (TPD(I),FTPD(I),TPD(I+N1),FTPD(I+N1),TPD(I+N2),
                 1   FTPD(I+N2),TPD(I+N3),FTPD(I+N3),I=1,NROW)
ISN 0039      500 FORMAT(4(E20.4,E13.4))
ISN 0040          IF(NLEFT.EQ.0) GO TO 5
ISN 0042          NROW = NROW + 1
ISN 0043          WRITE(6,500) (TPD(I*NROW),FTPD(I*NROW),I=1,NLEFT)
ISN 0044          GO TO 5
ISN 0045       10 END FILE 14
ISN 0046       20 STOP
ISN 0047          END
```

```
ISN 0002        SUBROUTINE READIT(NT,X,Y,N,TITLE,*,*)
ISN 0003        REAL*4 X(N),Y(N),TITLE(20)
ISN 0004        READ(NT,END=69) TITLE
ISN 0005        READ(NT,END=70) N
ISN 0006        READ(NT,END=70) X,Y
ISN 0007        RETURN
ISN 0008     69 RETURN 1
ISN 0009     70 WRITE(6,700)
ISN 0010    700 FORMAT(///' AN EOF HAS BEEN ENCOUNTERED IMPROPERLY, AND THIS PROCR
               1AM IS TERMINATING')
ISN 0011        RETURN 2
ISN 0012        END
```

```
ISN 0002        SUBROUTINE WRITED(NT,X,Y,N,TITLE)
ISN 0003        REAL*8 X(N),Y(N)
ISN 0004        REAL*4 TITLE(20)
ISN 0005        WRITE(NT) TITLE
ISN 0006        WRITE(NT) N
ISN 0007        WRITE(NT) X,Y
ISN 0008        RETURN
ISN 0009        END
```

APPENDIX B.--A LISTING OF THE PROGRAM TRANS2

```
LEVEL 2.3  (JULY 75)                    [illegible] FORTRAN H EXTENDED PLUS        DATE 77.[illegible]/[illegible].04.00        PAGE  1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE [illegible] INIT(00) SIZE(000000K) AUTODBL(DBL)
                   SOURCE ESCDIC [illegible] CHECK OBJECT [illegible] MAP NOREWRT NOOBJSTMT NOXREF [illegible] NOASSF NOTERMINAL FIPS(I)

                   FUNCTIONS INLINE ARE  NONE

                 C     PROGRAM TRANS.                                                                  .000100
                 C                                                                                     .000200
                       DIMENSION T(300),FT(300),TT(301),FTT(600)                                       .000300
ISN 0002               DIMENSION FPLT(2048),APPLT(2048),PHIPLT(2048),FAMP(2048)                        .000400
ISN 0003               DIMENSION TIME(257),CURNT1(750),CURNT2(750),CURRNT(750)                         .000500
ISN 0004               DIMENSION FT-AMP(25),ATRANS(25),C-EFF(4,25)                                     .000600
ISN 0005               DIMENSION FPHASE(25),PHASE(25),C-EFF(4,25)                                      .000700
ISN 0006               DIMENSION NFITS(5)                                                              .000800
ISN 0007               INTEGER YLAB1(5)/4H  CU,4HRRE,4HT(AP,4HES) /                                    .000900
ISN 0008               INTEGER YLAB2(7)/4H  CU,4HRRE,4HNT ,4HOF I,4HNPUT,4H  VS,4HVOLT,4H   /          .001000
                      1       ,YLAB3(6)/4HCURR,4HENT ,4HOF I,4HNPUT,4H  VS,4HTIME,4H   /               .001100
                      2       ,YLAB4(7)/4HCURR,4HENT ,4HSENS,4HITY(,4HA/ME,4HTER),4H92) /              .001200
                      3       ,YLAB5(7)/4HCORR,4HTON ,4HCURR,4HENT ,4HTIME,4H VS,4HTLRY/               .001300
                      4       ,YLAB5(7)/4HCURR,4HENT (U,4HEEER,4HS/ME,4HTER),4H92 S,4HEC) /            .001400
                      5       ,YLAB6(6)/4HCURR,4HENT ,4HIDS ,4HLEIF,4H RES,4HPUNS,4HE   /              .001500
                      6       ,YLAB4(3)/4H  (A,4H/MET,4HER) /                                          .001600
                      7       ,YLAB4(7)/4HMASS,4HETIC,4H FIE,4HLD T,4HIME ,4HFIST,4HORY /              .001700
                      8       ,YLAB5(6)/4H  CU,4HRRENT,4HT(AN,4HPS) /                                  .001800
                      9       ,YLAB5(6)/4HFIE ,4HMAS,4HRESP,4HINSE/                                    .001900
                      1       ,YLAB6(8)/4H  CU,4H/DT ,4H(A/M,4HETER,4H92 ,4HSEC /                      .002000
                      2       ,YLAB6(5)/4HCONE-,4HTURN,4H RIC,4HLNSR,4HI CE,4HIL R,4HESPE,             .002100
                      3        4HASE /                                                                 .002200
                      4       ,YLAB7(4)/4H  J (,4HA/RE,4HTER,4H92) /                                   .002300
                      5       ,YLAB7(1)/4HCOUP,4HION ,4HCURR,4HENT ,4HTIME,4H VS,4HTLRY/               .002400
                      6       ,YLAB8(7)/4HCOUP,4HLE  ,4HCURR,4HENT ,4HTIME,4H VS,4HTLRY/               .002500
ISN 0009               INTEGER ALABEL(5)/4H  TI,4HME(,4HSEC) /                                         .002600
                      1       ,YLBL(3)/4H  AA,4HPLIT,4HUDE /                                           .002700
                      2       ,XLB(4)/4H PSE,4HCUEN,4HCY (,4HHZ) /                                     .002800
                      3       ,YLB(4)/4HPHAS,4HE (D,4HEGRE,4HES) /                                     .002900
                      4       ,PLB(7)/4HTRAN,4HSFER,4H FUN,4HCTIO,4HN AN,4HPLIT,4HUDE /                .003000
                      5       ,PLB(6)/4HTRAN,4HSFER,4H FUN,4HCTIO,4HN PH,4HASE /                       .003100
                      6       ,PLB3(7)/4H  F,4HREQU,4HENCY,4H DER,4HIVE ,4HRESU,4HLTS /                .003200
ISN 0010               INTEGER SLABEL(25)/4H  ...,4H CAL,4HCULA,4HTED,,4H   -,4H- RE,                  .003300
                      1        4HASUR,4HEDR ,12*4H    /                                                .003400
ISN 0011               INTEGER TITLE(20)                                                               .003500
ISN 0012               COMPLEX JJ,HMI                                                                  .003600
ISN 0013               COMPLEX FW(4096)                                                                .003700
                 C                                                                                     .003800
                 C     EQUIVALENCE ARRAYS TO REDUCE MEMORY REQUIREMENTS                                .003900
                 C                                                                                     .004000
ISN 0014               EQUIVALENCE(FW(1),FTT(1))                                                       .004100
ISN 0015               EQUIVALENCE (FPLT(1),T(1)),(FPLT(301),FT(1)),(FPLT(601),TT(1))                  .004200
ISN 0016               EQUIVALENCE (APPLT(1),TIME(1)),(APPLT(751),CURNT1(1),CURRNT(1))                 .004300
ISN 0017               EQUIVALENCE (PHIPLT(1),CURNT2(1))                                               .004400
                 C                                                                                     .004500
                 C     NDSETS IS THE NUMBER OF DATA SETS TO BE PROCESSED                               .004600
                 C     IF ISAME = 1, THE INPUT PARAMETERS FOR THE FIRST DATA SET ARE USED              .004700
                 C        FOR ALL THE DATA SETS, OTHERWISE INPUT PARAMETERS MUST BE                    .004800
                 C        PROVIDED FOR ALL THE DATA SETS                                               .004900
                 C                                                                                     .005000
ISN 0018               READ(5,500) NDSETS,ISAME                                                        .005100
```

```
ISN 0019          WRITE(6,555) NDSETS,ISAME                                  0051000
ISN 0020      555 FORMAT(7H NDSETS =,I3,5X,7HISAME =,I2)                     0052000
ISN 0021          DO 9 IDSETS=1,NDSETS                                       0053000
            C                                                                0054000
            C     READ THE DATA FROM LOGICAL UNIT 8                          0055000
            C                                                                0056000
ISN 0022          CALL READTP(R,T,FT,NPTS,TITLE,89)                          0057000
            C                                                                0058000
ISN 0023       14 IF(NPTS.GT.300) GO TO 5                                    0059000
ISN 0025          WRITE(6,100) (TITLE(I),I=1,8)                              0060000
ISN 0026      100 FORMAT(1H1,20A4)                                           0061000
ISN 0027          IF(ISAME.EQ.1   .AND.   IDSETS.GE.1)  GO TO 23             0062000
            C                                                                0063000
            C     NOFF IS THE NUMBER OF DATA POINTS REMOVED FROM THE FRONT OF THE   0064000
            C        PULSE                                                   0065000
            C     NOFFR IS THE NUMBER OF DATA POINTS REMOVED FROM THE REAR OF THE   0066000
            C        PULSE                                                   0067000
            C     IF INVERT = 1, THE PULSE IS INVERTED, OTHERWISE IT IS NOT  0068000
            C     IF IZERO = 1, THE AMPLITUDES OF THE FIRST AND LAST DATA POINTS ARE 0069000
            C        EQUAL TO ZERO                                           0070000
            C     IF IPLOT = 1,THE INPUT DIGITIZED DATA IS PLOTTED           0071000
            C     IF IFILE = 1, THE PROCESSED DATA IS WRITTEN ON LOGICAL UNIT 9 SO  0072000
            C        THAT IT CAN BE CATALOGED AS A DISK FILE                 0073000
            C                                                                0074000
            C     ISENSR DENOTES THE TYPE OF SENSOR WHICH WAS USED TO PRODUCE THE   0075000
            C        DATA                                                    0076000
            C        1 = CURRENT PROBE USED TO MEASURE CURRENT ON INNER CYLINDER   0077000
            C        2 = CURRENT PROBE USED TO MEASURE CURRENT ON A SINGLE WIRE   0078000
            C        3 = CURRENT PROBE USED TO MEASURE CENTER CURRENT          0079000
            C        4 = MOBIUS LOOP                                           0080000
            C        5 = CURRENT PROBE ON FIN PAN                              0081000
            C        6 = ONE-TURN RESONANT COIL                                0082000
            C                                                                0083000
ISN 0029          READ(5,500) NOFF,NOFFR,INVERT,IZERO,IPLOT,IFILE,ISENSR     0084000
ISN 0030      500 FORMAT(7I10)                                               0085000
            C                                                                0086000
            C     IF IPLTC = 1, THE COUPLED CURRENT OUTPUT FROM SAPSC IS PLOTTED ON  0087000
            C        SAME GRAPH AS THE PROCESSED DATA                        0088000
            C     IF NCUR = 1, SAPSC OUTPUT FOR THE FIRST MEASUREMENT POSITION IS   0089000
            C        PLOTTED.  OTHERWISE, THE OUTPUT FOR THE SECOND POSITION IS PLOTTED  0090000
            C                                                                0091000
ISN 0031          READ (5,500) IPLTC,NCUR                                    0092000
            C                                                                0093000
            C     NSTAR IS THE NUMBER OF FREQUENCY AND TIME POINTS USED IN THE FFT  0094000
            C     FMAX IS THE MAXIMUM FREQUENCY USED IN THE FFT              0095000
            C     IF KPLOT = 1, FREQUENCY DOMAIN RESULTS ARE PLOTTED         0096000
ISN 0032          READ (5,501) NSTAR,FMAX,KPLOT                              0097000
ISN 0033      501 FORMAT(I10,2F10.0,I10)                                     0098000
            C                                                                 0099000
            C     NTRANS IS THE NUMBER OF TRANSFER FUNCTION AMPLITUDE POINTS TO BE  0100000
            C        USED (25 OR LESS)                                       0101000
            C     IF JPLOT = 1, THE TRANSFER FUNCTION AMPLITUDE AND PHASE ARE  0102000
            C        PLOTTED                                                 0103000
            C     IF IPHASE = 1, PHASE WILL BE INCLUDED IN THE TRANSFER FUNCTION  0104000
            C                                                                0105000
ISN 0034          READ(5,500) NTRANS,JPLOT,IPHASE                            0106000
            C                                                                0107000
            C     FTRANS IS THE FREQUENCY (HZ), AND ATRANS IS THE AMPLITUDE  0108000
```

```
                C        (AMPS/VOLT) OF THE MEASURED TRANSFER FUNCTION
                C
ISN 0035              READ(5,510) (FTRANS(I),ATRANS(I),I=1,NTRANS)
ISN 0036          510 FORMAT(4(2E10.3))
ISN 0037              TRETRD = 0.
ISN 0038              IF(IPHASE.NE.1) GO TO 24
                C
                C     NPHASE IS THE NUMBER OF PHASE POINTS TO BE USED (25 OR LESS)
                C     TRETRD IS THE AMOUNT OF TIME (IN SEC) WHICH THE PULSE MUST BE
                C        RETARDED IF THE TRANSFER FUNCTION INCLUDES PHASE
                C
ISN 0040              READ(5,501) NPHASE,TRETRD
                C
                C     FPHASE IS THE FREQUENCY (HZ), AND APHASE IS THE PHASE ANGLE
                C        (DEGREES) OF THE MEASURED PHASE
                C
ISN 0041              READ(5,510) (FPHASE(I),PHASE(I),I=1,NPHASE)
                C
                C     WRITE THE INPUT PARAMETERS
                C
ISN 0042           24 WRITE(6,550) NOFF,NOFFR,INVERT,IZERO,IPLOT,IFILE,ISENSR
ISN 0043          550 FORMAT(////7H NOFF =,I3,5X,7HNOFFR =,I3,5X,8HINVERT =,I2,5X,
                     1   7HIZERO =,I2,5X,7HIPLOT =,I2,5X,7HIFILE =,I2,5X,8HISENSR =,I2/)
ISN 0044              WRITE (6,554) IPLTC,NCUR
ISN 0045          554 FORMAT(8H IPLTC =,I2,5X,6HNCUR =,I2/)
ISN 0046              WRITE(6,551) NSTAR,FMAX,KPLOT
ISN 0047          551 FORMAT(6H NSTAR =,I6,5X,6HFMAX =,E10.3,5X,7HKPLOT =,I2/)
ISN 0048              WRITE(6,570) NTRANS,JPLOT,IPHASE
ISN 0049          570 FORMAT(9H NTRANS =,I3,5X,7HJPLOT =,I2,5X,8HIPHASE =,I2/)
ISN 0050              WRITE(6,571)
ISN 0051          571 FORMAT(7X,6HFTRANS,6X,6HATRANS,4(8X,6HFTRANS,6X,6HATRANS))
ISN 0052              WRITE(6,602) (FTRANS(I),ATRANS(I),I=1,NTRANS)
ISN 0053              IF(IPHASE.NE.1) GO TO 23
ISN 0055              WRITE(6,572) NPHASE,TRETRD
ISN 0056          572 FORMAT(9HONPHASE =,I3,5X,8HTRETRD =,E10.3/)
ISN 0057              WRITE(6,573)
ISN 0058          573 FORMAT(7X,6HFPHASE,6X,5HPHASE,4(9X,6HFPHASE,6X,5HPHASE))
ISN 0059              WRITE(6,602) (FPHASE(I),PHASE(I),I=1,NPHASE)
                C
                C     REMOVE DATA POINTS FROM REAR OF PULSE
                C
ISN 0060           23 NPTS = NPTS - NOFFR
                C
ISN 0061              IF(INVERT.NE.1) GO TO 26
                C
                C     INVERT INPUT DATA
                C
ISN 0063              DO 25 I=1,NPTS
ISN 0064           25 FT(I) = -FT(I)
                C
ISN 0065           26 IF(NOFF.EQ.0) GO TO 27
                C
                C     REMOVE DATA POINTS FROM FRONT OF PULSE
                C
ISN 0067              NPTS = NPTS - NOFF
ISN 0068              FN1 = T(NOFF+1)
ISN 0069              DO 75 I=1,NPTS
ISN 0070              FT(I) = FT(I+NOFF)
```

```
LEVEL 2.1  (JULY 75)          MAIN          OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/08.04.00        PAGE   4

  ISN 0071          T(I) = T(I+NLEF) - TN1                                          0016000
  ISN 0072       75 CONTINUE                                                        0016000
  ISN 0073          NPTS = NETS                                                     0016000
                 C                                                                  0017000
  ISN 0074       27 IF(IPHASE.NE.1) GO TO 33                                        0017000
  ISN 0076          NN = NPTS + 1                                                   0017000
  ISN 0077          IF(NN.GT.300) GO TO 5                                           0017000
                 C                                                                  0017000
                 C     SINCE THE SIGNAL IS DELAYED BY THE MEASURING SYSTEM, THE PULSE 0017000
                 C        MUST BE RETARDED IN REAL TIME BEFORE IT CAN BE MULTIPLIED BY 0017000
                 C        THE PHASE FACTOR OF THE TRANSFER FUNCTION                  0017000
                 C                                                                  0017000
  ISN 0079       95 FT(NN) = FT(NN-1)                                               0017000
  ISN 0080          T(NN) = T(NN-1) + TREPRO                                        0017000
  ISN 0081          NN = NN - 1                                                     0017000
  ISN 0082          IF(NN.GT.1) GO TO 95                                            0018000
  ISN 0084          NPTS = NPTS + 1                                                 0018000
  ISN 0085          T(1) = 0.                                                       0018000
  ISN 0086          FT(1) = 0.                                                      0018000
                 C                                                                  0018000
  ISN 0087       33 WRITE(6,200) NPTS                                               0018000
  ISN 0088      200 FORMAT(1H0,6HNPTS =,I4///)                                      0018000
                 C                                                                  0019000
  ISN 0089          IF(IZERO.NE.1) GO TO 29                                         0019000
                 C                                                                  0019000
                 C     SET THE AMPLITUDES OF THE FIRST AND LAST POINTS EQUAL TO ZERO 0019000
                 C                                                                  0019000
  ISN 0091          FT(1) = 0.                                                      0019000
  ISN 0092          FT(NPTS) = 0.                                                   0019000
                 C                                                                  0019000
  ISN 0093       29 IF(IPLOT.NE.1) GO TO 55                                         0019000
                 C                                                                  0019000
                 C     PLOT THE INPUT DATA                                          0019000
                 C                                                                  0020000
  ISN 0095          CALL DRAW41(1,3,3,20,0,XLABEL,YLBL,TITLE,0.)                    0020000
  ISN 0096          CALL DRAW42(1,1,NPTS,0,1G,T,FT,0.,0.)                           0020000
  ISN 0097          CALL DRAW43(1,1,0,0,+NPTS,T ,FT ,2.,0.)                         0020000
                 C                                                                  0020000
                 C     ASSIGN SENSOR RESPONSE FUNCTIONS                             0020000
                 C                                                                  0020000
  ISN 0098       55 GO TO (49,48,47,46,45,44),ISENSR                                0021000
                 C                                                                  0021000
                 C     CURRENT MUST BE MULTIPLIED BY THE NUMBER OF RESISTORS IN THE BANJ0020000
                 C                                                                  0021000
  ISN 0099       49 SENSOR = 20.                                                    0021000
  ISN 0100          GO TO 21                                                        0021000
                 C                                                                  0021000
  ISN 0101       46 SENSOR = 1.                                                     0021000
  ISN 0102          GO TO 21                                                        0021000
                 C                                                                  0021000
  ISN 0103       47 DIAM = 1.875*.0254                                              0021000
  ISN 0104          AREA = 3.14159*(DIAM/2.)**2                                     0021000
                 C                                                                  0021000
                 C     CURRENT MUST BE DIVIDED BY AREA OF SENSOR                    0022000
                 C                                                                  0022000
  ISN 0105          SENSOR = 1./AREA                                                0022000
  ISN 0106          GO TO 21                                                        0022000
                 C                                                                  0022000
```

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LEVEL 2.1  (JULY 79)          MAIN          IS/360  FORTRAN H EXTENDED PLUS        DATE 77.088/04.34.07          PAGE   5

 ISN 0107          46 SENSOR = (1./1.14E-3)**2.4
 ISN 0108             GO TO 21
                C
 ISN 0109          45 SENSOR = 1.
 ISN 0110             GO TO 21
                C
 ISN 0111          44 VOLUME = 5.E-2
 ISN 0112             SENSOR = (1.E-7/VOLUME)**2.4
 ISN 0113          21 DO 20 I=1,NPTS
 ISN 0114          20 FT(I) = FT(I)*SENSOR
                C
                C     CALCULATE FREQUENCY AND TIME SPACING
                C
 ISN 0115             DF = FMAX/(NSTAR-1)
 ISN 0116             DT = 1./(NSTAR*DF)
                C
                C     LINEARLY INTERPOLATE THE INPUT DATA
                C
 ISN 0117             CALL CLINTD(T,FT,NPTS,NSTAR,DT,FW)
                C
 ISN 0118             TNPTS = T(NPTS)
 ISN 0119             NTF = (TNPTS - THETFD)/DT + 1
 ISN 0120             IF(NTF.GT.R01) GO TO 4
                C
                C     CALCULATE WHAT POWER OF 2 NSTAR IS
                C
 ISN 0122             NPOW = 0
 ISN 0123             NREM = NSTAR
 ISN 0124          22 NREM = NREM/2
 ISN 0125             NPOW = NPOW + 1
 ISN 0126             IF(NREM.NE.1) GO TO 22
                C
                C
                C     TRANSFORM DATA INTO FREQUENCY DOMAIN
                C
 ISN 0128             CALL FFTD(FW,NPOW,NSTAR,DT,-1)
                C
 ISN 0129             NS21 = NSTAR/2 + 1
                C
                C     CALCULATE SPLINE FUNCTION COEFFICIENTS FOR TRANSFER FUNCTION
                C        AMPLITUDE DATA
                C
 ISN 0130             CALL SPLICU(NTRANS,FTRANS,ATRANS,COEF)
                C
                C     CALCULATE SPLINE FUNCTION COEFFICIENTS FOR PHASE DATA
                C
 ISN 0131             IF(IPHASE.EQ.1) CALL SPLICU(NPHASE,FPHASE,PHASE,COEFP)
                C
                C     INITIALIZE STARTING POINT OF SEARCH THROUGH TRANSFER FUNCTION DATA
                C
 ISN 0133             JSTART = 1
 ISN 0134             KSTART = 1
                C
                C     INITIALIZE FLAG FOR CALCULATION OF PARAMETERS FOR FITS
                C        TO FRONT AND REAR OF TRANSFER FUNCTION
                C
 ISN 0135             KFIT(1) = 1
 ISN 0136             KFIT(2) = 1
```

```
ISN 0137          KFIT(3) = 1
ISN 0138          KFIT(4) = 1
            C
ISN 0139          PIRAD = 3.14159/180.
ISN 0140          EPHI = (1.,0.)
ISN 0141          JJ = (0.,1.)
            C
ISN 0142          DO 30 I=1,NS21
ISN 0143          F = DF*(I - 1)
ISN 0144          IF(F.LE.FTRANS(NTRANS)) GO TO 31
            C
            C     PERFORM FIT TO REAR OF TRANSFER FUNCTION AMPLITUDE DATA
            C
ISN 0146          CALL ENDFIT(2,KFIT(2),NTRANS,FTRANS,ATRANS,F,AMP)
ISN 0147          GO TO 34
            C
ISN 0148       31 IF(F.GE.FTRANS(1)) GO TO 32
            C
            C     PERFORM FIT TO FRONT OF TRANSFER FUNCTION AMPLITUDE DATA
            C
ISN 0150          CALL ENDFIT(1,KFIT(1),NTRANS,FTRANS,ATRANS,F,AMP)
ISN 0151          GO TO 34
            C
            C     USE SPLINE FUNCTION TO CALCULATE VALUE OF TRANSFER FUNCTION
            C        AMPLITUDE AT DESIRED FREQUENCY
            C
ISN 0152       32 CALL SPLINE(KSTART,FTRANS,ATRANS,CEEF,F,AMP)
            C
ISN 0153       34 IF(IPHASE.NE.1) GO TO 29
ISN 0155          IF(F.LE.FPHASE(NPHASE)) GO TO 35
            C
            C     PERFORM FIT TO REAR OF PHASE DATA
            C
ISN 0157          CALL ENDFIT(4,KFIT(4),NPHASE,FPHASE,PHASE,F,PHI)
            C
ISN 0158          GO TO 36
ISN 0159       35 IF(F.GE.FPHASE(1)) GO TO 37
            C
            C     PERFORM FIT TO FRONT OF PHASE DATA
            C
ISN 0161          CALL ENDFIT(3,KFIT(3),NPHASE,FPHASE,PHASE,F,PHI)
ISN 0162          GO TO 36
            C
            C     USE SPLINE FUNCTION TO CALCULATE VALUE OF PHASE AT DESIRED
            C        FREQUENCY
            C
ISN 0163       37 CALL SPLINE(JSTART,FPHASE,PHASE,CHEEP,F,PHI)
            C
            C     CALCULATE TRANSFER FUNCTION PHASE EFFECTS
            C
ISN 0164       36 EPHI = CEXP(-JJ*PHI*PIRAD)
            C
            C     MULTIPLY BY TRANSFER FUNCTION
            C
            C
ISN 0165       29 FX(I) = FX(I)*AMP*EPHI
            C
ISN 0166          FPLT(I) = F
```

```
ISN 0167          AMPPLT(I) = AMP                                          00341000
ISN 0168          PHIPLT(I) = PHI                                          00342000
ISN 0169          FAMP(I) = (ABS(FW(I))                                    00343000
ISN 0170       30 CONTINUE                                                 00344000
            C                                                              00345000
ISN 0171          IF(JPLOT.NE.1) GO TO 38                                  00346000
ISN 0173          IF(ISAME.EQ.1  .AND.  IDSETS.NE.1) GO TO 38              00347000
            C                                                              00348000
            C     PLOT TRANSFER FUNCTION                                   00349000
            C                                                              00350000
ISN 0175          CALL DRAWID(3,4,3,7,0,NS21,2.,0.,XLB,YLBL,PLB,0.,FPLT,AMPPLT)  00351000
            C                                                              00352000
ISN 0176          IF(IPHASE.NE.1) GO TO 38                                 00353000
ISN 0178          CALL DRAWID(3,4,4,6,0,NS21,2.,0.,XLB,YLB,PLB2,0.,FPLT,PHIPLT)  00354000
            C                                                              00355000
ISN 0179       38 IF(KPLOT.NE.1) GO TO 39                                  00356000
            C                                                              00357000
            C     PLOT FREQUENCY DOMAIN RESULTS                            00358000
            C                                                              00359000
ISN 0181          CALL DRAWID(2,4,3,7,20,NS21,2.,0.,XLB,YLBL,PLB3,TITLE,FPLT,FAMP)  00360000
            C                                                              00361000
            C     TRANSFORM DATA BACK INTO THE TIME DOMAIN                 00362000
            C                                                              00363000
ISN 0182       39 CALL FFTAD(2,FW,NSTAR,DF,1,.FALSE.,FTT)                  00364000
ISN 0183          FTT1 = FTT(1)                                            00365000
ISN 0184          WRITE(6,560) FTT1                                        00366000
ISN 0185      560 FORMAT(7H FTT1 =,E10.3//)                                00367000
            C                                                              00368000
            C     REMOVE DC SHIFT FROM PROCESSED DATA                      00369000
            C                                                              00370000
ISN 0186          DO 70 I=1,NTP                                            00371000
ISN 0187          TT(I) = DT*(I-1)                                         00372000
ISN 0188          FTT(I) = FTT(I) - FTT1                                   00373000
ISN 0189       70 CONTINUE                                                 00374000
ISN 0190          WRITE(6,601)                                             00375000
ISN 0191      601 FORMAT(10X,1HT,10X,2HFT,13X,1HT,10X,2HFT,13X,1HT,10X,2HFT,  00376000
                 1   13X,1HT,10X,2HFT,13X,1HT,10X,2HFT)                    00377000
ISN 0192          WRITE(6,602) (TT(I),FTT(I),I=1,NTP)                      00378000
ISN 0193      602 FORMAT(5(E14.3,E12.3))                                   00379000
            C                                                              00380000
            C     PLOT PROCESSED DATA                                      00381000
            C                                                              00382000
ISN 0194          GO TO (69,68,67,66,65,64),ISENSR                         00383000
            C                                                              00384000
ISN 0195       69 IF (IPLTC.NE.1) GO TO 77                                 00385000
            C                                                              00386000
            C     READ SAPSC COUPLED CURRENT OUTPUT FROM LOGICAL UNIT 10   00387000
            C                                                              00388000
ISN 0197          READ(10) NL                                              00389000
ISN 0198          READ(10) (TIME(I),CURNT1(I),CURNT2(I),I=1,NL)            00390000
ISN 0199          DO 72 I=9,20                                             00391000
ISN 0200       72 SLABEL(I) = TITLE(I-8)                                   00392000
ISN 0201          NTL = NTP                                                00393000
ISN 0202          IF (NL.GT.NTP) NTL=NL                                    00394000
            C                                                              00395000
            C     CURNT AND CURNT1 HAVE BEEN EQUIVALENCED                  00396000
            C                                                              00397000
ISN 0204          IF (NCUR.EQ.1) GO TO 73                                  00398000
```

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ISN 0206          DO 74 I=1,NL                                          00394000
ISN 0207       74 CURNT(I) = CURNT2(I)                                  00400000
              C                                                         00401000
              C   PLOT SAPSC OUTPUT ON SAME GRAPH AS PROCESSED DATA     00402000
              C                                                         00403000
ISN 0208       73 CALL DRAW41(1,3,4,7,20,XLABEL,YLAB1,PLAB1,SLABEL)     00404000
ISN 0209          CALL DRAW42(1,1,NTP,0.  1,TT,FTT,0.,0.)               00405000
ISN 0210          CALL DRAW42(1,1,NL,0.  2,TIME,CURNT,0.,0.)            00406000
ISN 0211          CALL DRAW43(1,1,0,0,NTL,TT,FTT,2.,0.)                 00407000
ISN 0212          GO TO 80                                              00408000
              C                                                         00409000
ISN 0213       77 CALL DRAWID(1,3,4,7,20,NTP,2.,0.,XLABEL,YLAB1,PLAB1,TITLE,TT,FTT) 00410000
ISN 0214          GO TO 80                                              00411000
              C                                                         00412000
ISN 0215       68 CALL DRAWID(1,3,4,7,20,NTP,2.,0.,XLABEL,YLAB5,PLAB8,TITLE,TT,FTT) 00413000
ISN 0216          GO TO 80                                              00414000
              C                                                         00415000
ISN 0217       67 CALL DRAWID(1,3,7,7,20,NTP,2.,0.,XLABEL,YLAB2,PLAB2,TITLE,TT,FTT) 00416000
ISN 0218          GO TO 80                                              00417000
              C                                                         00418000
ISN 0219       66 CALL DRAWID(1,3,7,6,20,NTP,2.,0.,XLABEL,YLAB3,PLAB3,TITLE,TT,FTT) 00419000
ISN 0220          XMUINV = 1./1.26E-6                                   00420000
              C                                                         00421000
              C   INTEGRATE MOEBIUS LOOP DATA TO OBTAIN H FIELD         00422000
              C                                                         00423000
ISN 0221          AREA = 0.                                             00424000
ISN 0222          FTTI = FTT(1)                                         00425000
ISN 0223          FTT(1) = 0.                                           00426000
ISN 0224          DO 79 I=2,NTP                                         00427000
ISN 0225          FTTI1 = FTTI                                          00428000
ISN 0226          FTTI = FTT(I)                                         00429000
ISN 0227          AREA = AREA + .5*DT*(FTTI + FTTI1)                    00430000
ISN 0228          FTT(I) = AREA*XMUINV                                  00431000
ISN 0229       79 CONTINUE                                              00432000
ISN 0230          WRITE(6,603)                                          00433000
ISN 0231      603 FORMAT(1H1,8X,1HT,10X,4HH(T),4(11X,1HT,10X,4HH(T))/)  00434000
ISN 0232          WRITE(6,602) (TT(I),FTT(I), I=1,NTP)                  00435000
ISN 0233          CALL DRAWID(1,3,3,7,20,NTP,2.,0.,XLABEL,YLAB4,PLAB4,TITLE,TT,FTT) 00436000
ISN 0234          GO TO 80                                              00437000
              C                                                         00438000
ISN 0235       65 CALL DRAWID(1,3,4,4,20,NTP,2.,0.,XLABEL,YLAB5,PLAB5,TITLE,TT,FTT) 00439000
ISN 0236          GO TO 80                                              00440000
              C                                                         00441000
ISN 0237       64 CALL DRAWID(1,3,6,6,20,NTP,2.,0.,XLABEL,YLAB6,PLAB6,TITLE,TT,FTT) 00442000
              C                                                         00443000
              C   INTEGRATE ONE-TURN ROGOWSKI COIL DATA TO OBTAIN J COMPTON 00444000
              C                                                         00445000
ISN 0238          AREA = 0.                                             00446000
ISN 0239          FTTI = FTT(1)                                         00447000
ISN 0240          FTT(1) = 0.                                           00448000
ISN 0241          DO 89 I=2,NTP                                         00449000
ISN 0242          FTTI1 = FTTI                                          00450000
ISN 0243          FTTI = FTT(I)                                         00451000
ISN 0244          AREA = AREA + .5*DT*(FTTI + FTTI1)                    00452000
ISN 0245          FTT(I) = AREA                                         00453000
ISN 0246       89 CONTINUE                                              00454000
ISN 0247          WRITE(6,604)                                          00455000
ISN 0248      604 FORMAT(1H1,8X,1HT,10X,4HJ(T),4(11X,1HT,10X,4HJ(T))/)  00456000
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LEVEL 2.1  (JULY 75)          MAIN          OS/360  FORTRAN H EXTENDED PLUS      DATE 77.065/09.04.00        PAGE   9

 ISN 0249          WRITE(6,602) (TT(I),FTT(I), I=1,NTP)                          00457000
 ISN 0250          CALL DRAW1D(1,3,4,0,26,NTP,2.,0.,XLABEL,YLAB7,PLAB7,TITLE,TT,FTT) 00458000
            C                                                                    00459000
 ISN 0251        86 IF(IFILE.NE.1) GO TO 3                                       00460000
            C                                                                    00461000
            C       WRITE PROCESSED DATA ON LOGICAL UNIT 9 SO THAT IT CAN BE CATALOGED00462000
            C                                                                    00463000
 ISN 0253          CALL WRITTP(9,TT,FTT,NTP,TITLE)                               00464000
 ISN 0254        3 CONTINUE                                                      00465000
 ISN 0255          STOP                                                          00466000
 ISN 0256        6 WRITE(6,302)                                                  00467000
 ISN 0257      302 FORMAT(/////38H THE DIMENSION OF TT HAS BEEN EXCEEDED)        00468000
 ISN 0258          STOP                                                          00469000
 ISN 0259        5 WRITE(6,300)                                                  00470000
 ISN 0260      300 FORMAT(/////38H THE DIMENSION OF FT HAS BEEN EXCEEDED)        00471000
 ISN 0261          STOP                                                          00472000
 ISN 0262        7 WRITE(6,301)                                                  00473000
 ISN 0263      301 FORMAT(/////37H THE DIMENSION OF H HAS BEEN EXCEEDED)         00474000
 ISN 0264        9 STOP                                                          00475000
 ISN 0265          END                                                           00476000
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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.10        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                      FUNCTIONS INLINE ARE:   NONE

   ISN 0002           SUBROUTINE WRITTP(NT,X,Y,N,TITLE)                          00620000
   ISN 0003           REAL*4 X(N),Y(N)                                           00621000
   ISN 0004           INTEGER TITLE(20)                                          00622000
   ISN 0005           WRITE(NT) TITLE                                            00623000
   ISN 0006           WRITE(NT) N                                                00624000
   ISN 0007           WRITE(NT) X,Y                                              00625000
   ISN 0008           RETURN                                                     00626000
   ISN 0009           END                                                        00627000
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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.08        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOOOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                     FUNCTIONS INLINE ARE:   NONE

ISN 0002             SUBROUTINE READTP(NT,X,Y,N,TITLE,*)                                    00604000
ISN 0003             REAL*4 X(N),Y(N)                                                       00605000
ISN 0004             INTEGER TITLE(20)                                                      00606000
ISN 0005             READ(NT,ERR=11,END=12) TITLE                                           00607000
ISN 0006             READ(NT,ERR=11,END=12) N                                               00608000
ISN 0007             READ(NT,ERR=11,END=12) X,Y                                             00609000
ISN 0008             RETURN                                                                 00610000
ISN 0009          11 WRITE(6,420)                                                           00611000
ISN 0010         420 FORMAT(//65H **AN ERROR OCCURRED WHEN THE DATA WERE READ FROM THE 00612000
                    1DISK FILE**)                                                           00613000
ISN 0011             RETURN 1                                                               00614000
ISN 0012          12 WRITE(6,421)                                                           00615000
ISN 0013         421 FORMAT(// 68H **AN END OF FILE WAS ENCOUNTERED IMPROPERLY WHEN THE00616000
                    1DATA WERE READ FROM THE DISK FILE**)                                   00617000
ISN 0014             RETURN 1                                                               00618000
ISN 0015             END                                                                    00619000
```

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                C                                                          00594000
ISN 0032              BETA = (Y(M) - Y(M-1))/(X(M) - X(M-1))               00595000
ISN 0033              B = Y(M)                                             00596000
ISN 0034              KF = 2                                               00597000
                C                                                          00598000
                C     CALCULATE PHASE AT FREQUENCY ABOVE MEASURED PHASE    00599000
                C                                                          00600000
ISN 0035           41 YA = BETA*(XA - X(M)) + B                            00601000
ISN 0036              RETURN                                               00602000
ISN 0037              END                                                  00603000
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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.065/09.04.06        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0560K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOOPSTMT NOXREF NOALC NOAGSE NOTERMINAL FLAG(I)

                      FUNCTIONS INLINE ARE:   NONE

ISN 0002              SUBROUTINE ENDFIT(LFIT,KF,M,X,Y,XA,YA)                                    0054000
                C                                                                               0054500
                C     THIS SUBROUTINE CALCULATES THE TRANSFER FUNCTION AMPLITUDE OR             0054600
                C        PHASE VALUES OUTSIDE THE BOUNDS OF THE MEASURED VALUES                 0054700
                C                                                                               0054800
ISN 0003              DIMENSION X(1),Y(1)                                                       0054900
ISN 0004              GO TO (10,20,30,40),LFIT                                                  0055000
ISN 0005           10 IF(KF.NE.1) GO TO 11                                                      0055100
                C                                                                               0055200
                C     CALCULATE PARAMETERS FOR FIT TO FRONT OF TRANSFER                         0055300
                C        FUNCTION AMPLITUDE DATA                                                0055400
                C                                                                               0055500
ISN 0007              KF = 2                                                                    0055600
                C                                                                               0055700
                C     CALCULATE TRANSFER FUNCTION AMPLITUDE BELOW MEASURED DATA                 0055800
                C                                                                               0055900
ISN 0008           11 YA = 1000.                                                                0056000
ISN 0009              RETURN                                                                    0056100
ISN 0010           20 IF(KF.NE.1) GO TO 21                                                      0056200
                C                                                                               0056300
                C     CALCULATE PARAMETERS FOR FIT TO REAR OF TRANSFER                          0056400
                C        FUNCTION AMPLITUDE DATA                                                0056500
                C                                                                               0056600
ISN 0012              A = Y(M)                                                                  0056700
ISN 0013              ALPHA = ALOG(2.)/(100.E6 - X(M))                                          0056800
ISN 0014              KF = 2                                                                    0056900
                C                                                                               0057000
                C     CALCULATE TRANSFER FUNCTION AMPLITUDE ABOVE MEASURED DATA                 0057100
                C                                                                               0057200
ISN 0015           21 IF(XA.LT.100.E6) GO TO 25                                                 0057300
ISN 0017              YA = 0.                                                                   0057400
ISN 0018              RETURN                                                                    0057500
ISN 0019           25 IF((ALPHA*(XA - X(M))).GT.1.E-6) GO TO 22                                 0057600
ISN 0021              YA = A                                                                    0057700
ISN 0022              GO TO 23                                                                  0057800
ISN 0023           22 YA = A*(2. - EXP(ALPHA*(XA - X(M))))                                      0057900
ISN 0024           23 RETURN                                                                    0058000
ISN 0025           30 IF(KF.NE.1) GO TO 31                                                      0058100
                C                                                                               0058200
                C     CALCULATE PARAMETERS FOR FIT TO FRONT OF PHASE DATA                       0058300
                C                                                                               0058400
ISN 0027              KF = 2                                                                    0058500
                C                                                                               0058600
                C     CALCULATE PHASE AT FREQUENCY BELOW MEASURED PHASE                         0058700
                C                                                                               0058800
ISN 0028           31 YA = 180.                                                                 0058900
ISN 0029              RETURN                                                                    0059000
ISN 0030           40 IF(KF.NE.1) GO TO 41                                                      0059100
                C                                                                               0059200
                C     CALCULATE PARAMETERS FOR FIT TO REAR OF PHASE DATA                        0059300
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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.05        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                      FUNCTIONS INLINE ARE:   NONE

  ISN 0002            SUBROUTINE SPLINE(K,X,Y,C,XA,YA)                                    00523000
                C                                                                         00524000
                C     THIS SUBROUTINE USES A SPLINE FIT TO CALCULATE THE VALUE OF THE     00525000
                C     TRANSFER FUNCTION AMPLITUDE OR PHASE VALUES AT A GIVEN FREQUENCY    00526000
                C                                                                         00527000
  ISN 0003            DIMENSION X(1),Y(1),C(4,1)                                          00528000
                C                                                                         00529000
                C     SEARCH FOR PROPER FREQUENCY INTERVAL                                00530000
                C                                                                         00531000
  ISN 0004         29 IF(X(K+1).GE.XA) GO TO 30                                           00532000
  ISN 0006            K = K + 1                                                           00533000
  ISN 0007            GO TO 29                                                            00534000
  ISN 0008         30 XKI = X(K+1) - XA                                                   00535000
                C                                                                         00536000
                C     CALCULATE AMPLITUDE OR PHASE VALUE USING COEFFICIENTS FROM SPLICE   00537000
                C                                                                         00538000
  ISN 0009            YA = XKI*(C(1,K)*(XKI)**2 + C(3,K))                                 00539000
  ISN 0010            XKI = XA - X(K)                                                     00540000
  ISN 0011            YA = YA + XKI*(C(2,K)*(XKI)**2 + C(4,K))                            00541000
  ISN 0012            RETURN                                                              00542000
  ISN 0013            END                                                                 00543000
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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.03        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGESTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                     FUNCTIONS INLINE ARE:   NONE

 ISN 0002              SUBROUTINE SPLICD(M,X,Y,C)                                    00477000
                 C                                                                   00478000
                 C     THIS SUBROUTINE CALCULATES COEFFICIENTS FOR A SPLINE FIT TO   00479000
                 C     TRANSFER FUNCTION DATA                                        00480000
                 C                                                                   00481000
 ISN 0003              DIMENSION D(25),P(25),E(25),A(25,3),B(25),Z(25)               00482000
 ISN 0004              DIMENSION X(1),Y(1),C(4,1)                                    00483000
 ISN 0005              EQUIVALENCE(B(1),Z(1))                                        00484000
 ISN 0006              MM=M-1                                                        00485000
 ISN 0007              DO 2  K=1,MM                                                  00486000
 ISN 0008              D(K)=X(K+1)-X(K)                                              00487000
 ISN 0009              P(K)=D(K)/6.                                                  00488000
 ISN 0010            2 E(K)=(Y(K+1)-Y(K))/D(K)                                       00489000
 ISN 0011              DO 3  K=2,MM                                                  00490000
 ISN 0012            3 B(K)=E(K)-E(K-1)                                              00491000
 ISN 0013              A(1,3)=D(1)/D(2)                                              00492000
 ISN 0014              A(1,2)=-1.-A(1,3)                                             00493000
 ISN 0015              A(2,2)=2.*(P(1)+P(2))-P(1)*A(1,2)                             00494000
 ISN 0016              A(2,3)=(P(2)-P(1)*A(1,3))/A(2,2)                              00495000
 ISN 0017              B(2)=B(2)/A(2,2)                                              00496000
 ISN 0018              DO 4  K=3,MM                                                  00497000
 ISN 0019              A(K,2)=2.*(P(K-1)+P(K))-P(K-1)*A(K-1,3)                       00498000
 ISN 0020              B(K)=B(K)-P(K-1)*B(K-1)                                       00499000
 ISN 0021              A(K,3)=P(K)/A(K,2)                                            00500000
 ISN 0022            4 B(K)=B(K)/A(K,2)                                              00501000
 ISN 0023              Q=D(M-2)/D(M-1)                                               00502000
 ISN 0024              A(M,1)=1.+Q+A(M-2,3)                                          00503000
 ISN 0025              A(M,2)=-Q-A(M,1)*A(M-1,3)                                     00504000
 ISN 0026              B(M)=B(M-2)-A(M,1)*B(M-1)                                     00505000
 ISN 0027              Z(M)=B(M)/A(M,2)                                              00506000
 ISN 0028              MN=M-2                                                        00507000
 ISN 0029              DO 6  I=1,MN                                                  00508000
 ISN 0030              K=M-I                                                         00509000
 ISN 0031            6 Z(K)=B(K)-A(K,3)*Z(K+1)                                       00510000
 ISN 0032              Z(1)=-A(1,2)*Z(2)-A(1,3)*Z(3)                                 00511000
 ISN 0033              DO 7  K=1,MM                                                  00512000
 ISN 0034              Q=1./(6.*D(K))                                                00513000
 ISN 0035              C(1,K)=Z(K)*Q                                                 00514000
 ISN 0036              C(2,K)=Z(K+1)*Q                                               00515000
 ISN 0037              C(3,K)=Y(K)/D(K)-Z(K)*P(K)                                    00516000
 ISN 0038              C(3,K)=Y(K)/D(K)-Z(K)*P(K)                                    00517000
 ISN 0039            7 C(4,K)=Y(K+1)/D(K)-Z(K+1)*P(K)                                00518000
 ISN 0040              RETURN                                                        00519000
 ISN 0041              END                                                           00520000
                                                                                     00521000
                                                                                     00522000
```

APPENDIX C.--A LISTING OF THE PROGRAM PUNCH

```
LEVEL 2.1  (JULY 75) OS/360  FORTRAN H EXTENDED PLUS DATE 77.061/15.07.24 PAGE    1

REQUESTED OPTIONS: MAP

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT NOGOSTMT NOXREF
                   NOALC NOANSF NOTERMINAL FLAG(I)

                   FUNCTIONS INLINE ARE:   NONE


             C     PROGRAM PUNCH
             C
ISN 0002           INTEGER TITLE(20)
ISN 0003           REAL*8 TT(801),FTT(801)
ISN 0004           REAL*4 T(801),FT(801)
ISN 0005         1 CALL READDP(10,TT,FTT,NTP,TITLE,&10)
ISN 0006           DO 69 I=1,NTP
ISN 0007           T(I) = TT(I)
ISN 0008        69 FT(I) = FTT(I)
ISN 0009           PUNCH 100,(TITLE(I),I=1,20)
ISN 0010       100 FORMAT(20A4)
ISN 0011           PUNCH 200,NTP
ISN 0012       200 FORMAT(I10)
ISN 0013           PUNCH 300,(T(I),FT(I),I=1,NTP)
ISN 0014       300 FORMAT(3(2E12.4))
ISN 0015           GO TO 1
ISN 0016        10 STOP
ISN 0017           END
```

```
ISN 0002        SUBROUTINE READDP(NT,X,Y,N,TITLE,*)
ISN 0003        REAL*8 X(N),Y(N)
ISN 0004        INTEGER TITLE(20)
ISN 0005        READ(NT,ERR=11,END=10) TITLE
ISN 0006        READ(NT,ERR=11,END=12) N
ISN 0007        READ(NT,ERR=11,END=12) X,Y
ISN 0008        RETURN
ISN 0009     11 WRITE(6,420)
ISN 0010    420 FORMAT(//64H **AN ERROR OCCURRED WHEN THE DATA WAS READ FROM THE D
               1ISK FILE**)
ISN 0011        RETURN 1
ISN 0012     12 WRITE(6,421)
ISN 0013    421 FORMAT(// 87H **AN END OF FILE WAS ENCOUNTERED IMPROPERLY WHEN THE
               1DATA WAS READ FROM THE DISK FILE**)
ISN 0014     10 RETURN 1
ISN 0015        END
```

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